Soldier Creek-

Monitoring Stations- SC101, SC239, SC685
Biology Stations- SB299, Upper Soldier Creek; SB376, Halfday Creek
USGS Gaging Station- 06889200 (Lower Soldier) 10/1/1958-Current
Included area-

HUC 8: 10270102

HUC 10: 08

HUC 12: 01, 02, 03, 04, 05, 06, 07, 08

Streams Flowing to Monitoring Station-

Station	Name	Segment #
SC101	Soldier Cr-	9
Middle Soldier Creek	Soldier Cr-	9009
	James Creek-	87
	Dutch Cr-	92
	Crow Cr-	Tribal Stream
	S Br Soldier Creek-	Tribal Stream
SC239	Soldier Cr-	5
Lower Soldier Creek	Soldier Cr-	9
	Little Soldier Cr-	6
	Little Soldier Cr-	7
	Unnamed Stream-	8
	Walnut Cr-	91
	Messhoss Cr-	96
SC685	Little Soldier Cr-	7
Little Soldier Creek	Big Elm Cr-	90
Unmonitored Downstream	Soldier Cr-	5
	Halfday Cr-	97
	Indian Cr-	1365
	Unnamed Stream-	1367
	Unnamed Stream-	1389

Monitored Watershed Size- 339.2 square miles

Lower Soldier Creek (SC239) – 78.2 square miles
Middle Soldier Creek (SC101) – 155.3 square miles
Little Soldier Creek (SC685) – 60.9 square miles
Unmonitored Area – 40.4 square miles

Land use-

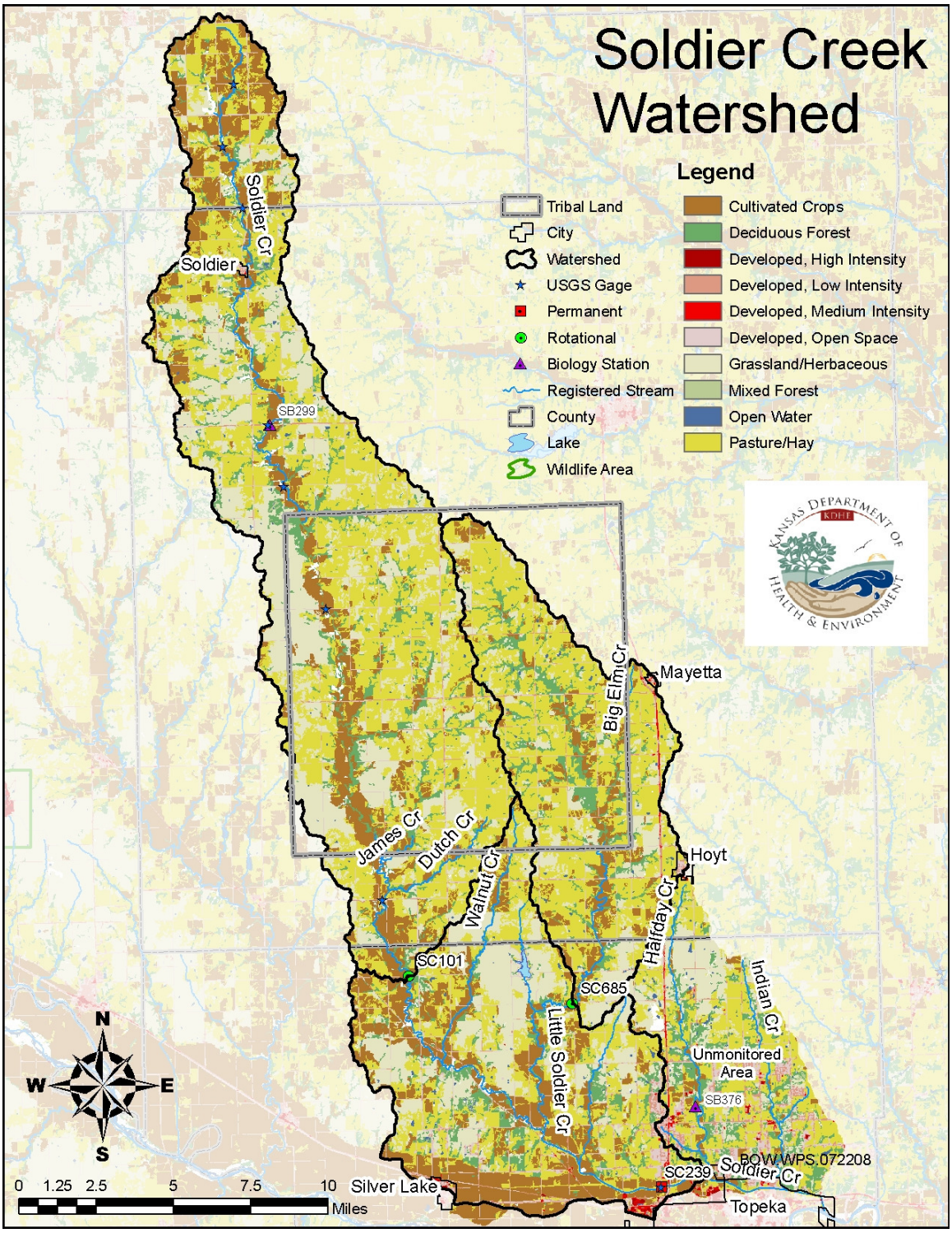
	Lower Soldier Creek	Middle Soldier Creek	Little Soldier Creek	Unmonitored Downstream Area
Permanent Grass	54.45%	69.69%	71.36%	58.42%
Cropland	26.65%	16.79%	11.78%	4.36%
Forest	10.08%	9.62%	11.35%	17.29%
Developed Land	7.86%	3.54%	4.93%	18.18%

Counties- Shawnee, Jackson & Nemaha
Cities- Soldier; Portions of Topeka, Silver Lake, Mayetta & Hoyt
2000 Population- Overall- 19,173[3]
Lower Soldier Creek (SC239) – 4,987
Middle Soldier Creek (SC101) – 1,482
Little Soldier Creek (SC685) – 2,330
Unmonitored Area – 12,027
Kansas House Districts – 50, 51, 57, 62
Kansas Senate Districts – 1, 18, 21

2008 303(d) impaired waters- Lower Soldier Creek, Biology
TMDLs- Biology, approved 8/3/2007 (SC101, SB299)
NPDES Permitted Facilities- Soldier MWTP (M-KS70-OO01), Soldier stormwater (M-KS87-SU01), Fairview North School (M-KS72-NO04), Northern Hills Jr./Sr. High (M-KS72-NO13), Seaman Sr. High (M-KS72-OO18), Shawnee North Community Center (M-KS72-OO06), Shawnee Co. M.S.D. #2- Indian Creek (M-KS72-OO24), Fairview Farms (I-KS72-NO01), Hill's (I-KS72-NO23), Hamm- Rolling Meadows #11 (I-KS72-PO20), KSNT (C-KS72-NO14), Northside Church of Christ (C-KS72-NO17), Northview Mobile Home Park (C-KS72-OO03)
Permitted Confined Animal Feeding Operations-12

Animal Type	Total Animals
Beef	1300
Dairy	390
Swine	10,295

[3] Individual monitoring station populations add up to greater than the total population due to census boundaries that cross watershed boundaries.



Overview map of the Soldier Creek watershed. Land use from the 2001 National Land Cover Dataset.

Stream Chemistry-

Water quality in the Soldier Creek drainage is consistently poor across all sites, parameters and seasons. The monitoring stations in the Soldier Creek watershed had overall ranks of 10 (Little Soldier), 13 (Lower Soldier) and 17 (Middle Soldier), placing them solidly in the lower half of streams included in this analysis. Middle Soldier has the worst water quality from a sediment/nutrient point of view during the summer-fall months, while Lower Soldier and Little Soldier show a more typical patterns with the worst water quality in the spring and relatively better quality during the summer-fall and winter months.

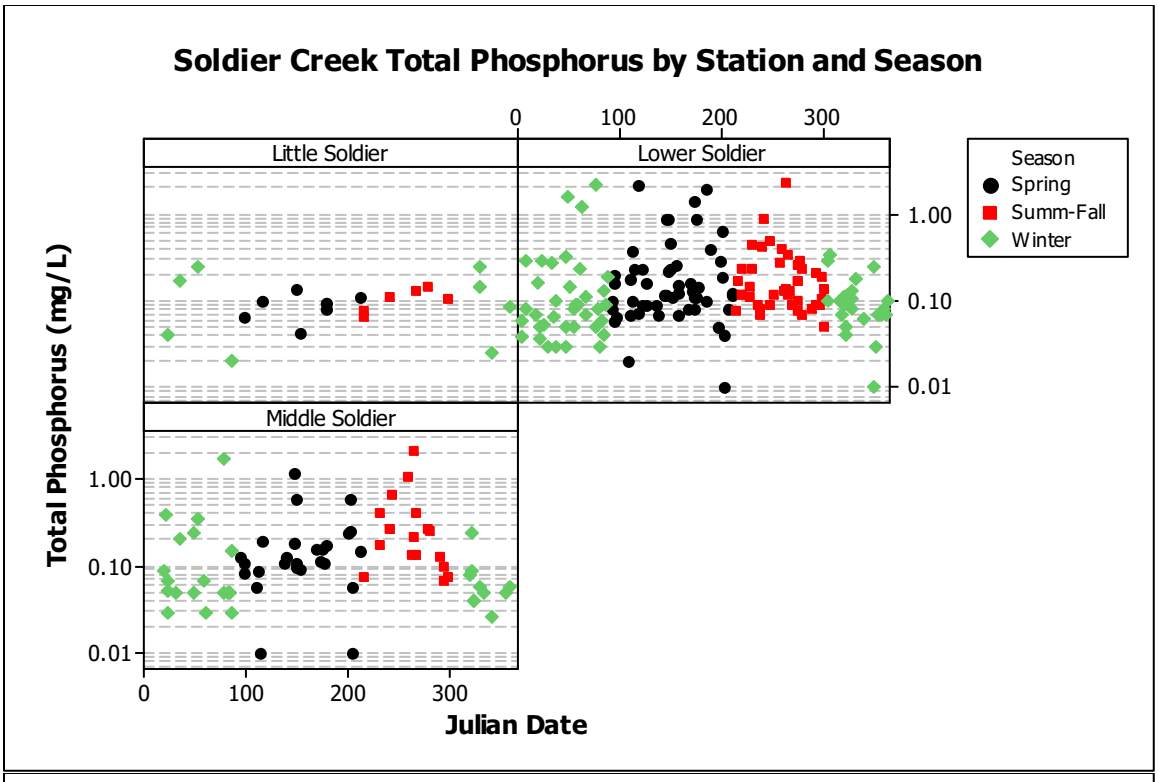
Middle Soldier has exceptionally high total suspended solids (TSS) concentrations for the Mid-Kansas area during both spring and summer-fall, with substantially lower concentrations during the winter. This is also somewhat apparent on the discharge graphs, where the winter data points tend to fall below the other seasons at lower flows, even as some of the highest recorded concentrations occurred during winter months when high discharge events occurred. This suggests that overland flow sources may be secondary to erosional bank areas for this stream, consistent with the work done previously to identify sources of sediment on Soldier Creek. More information regarding winter ground cover practices in the watershed would be helpful in assessing the relative potential of these two sources of sediments and nutrients. Bacteria data for Middle Soldier are limited, but at least some high bacteria events have occurred during the spring, and these appear to be unlinked to discharge at this location. There is some evidence that groundwater may be contributing to increases in nitrogen concentrations during low flow periods.

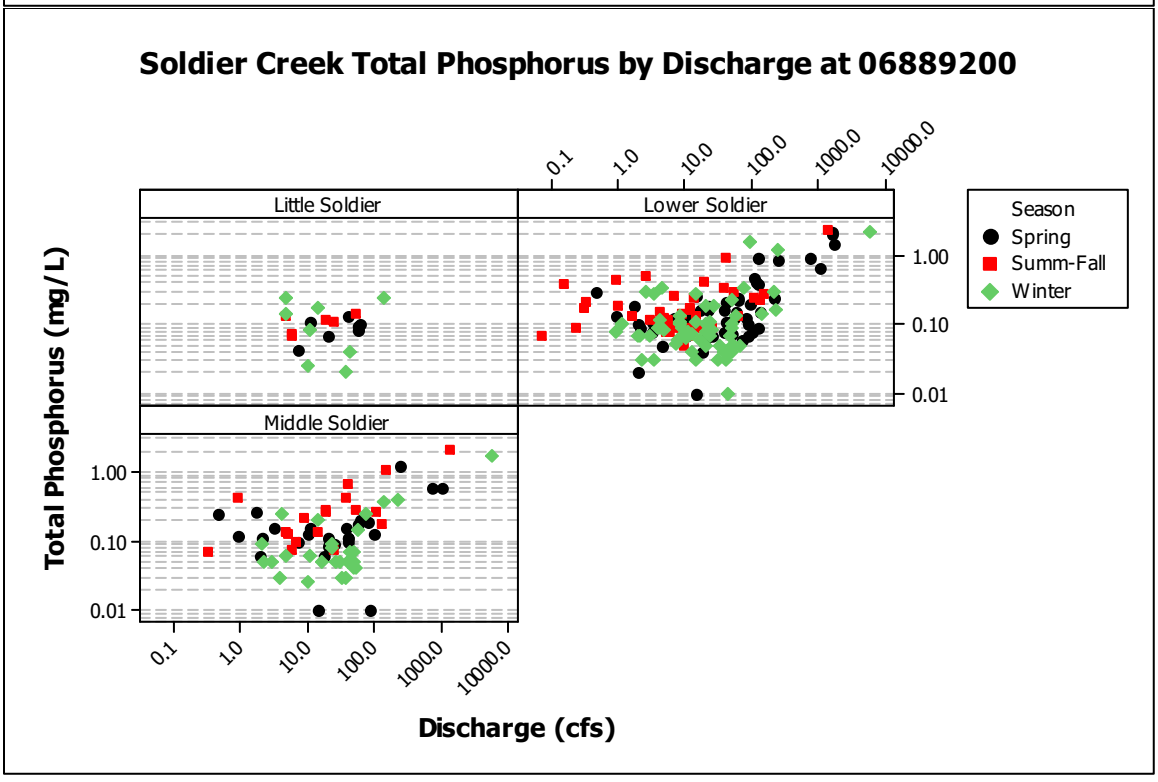
Little Soldier has a fairly small monitoring record, and shows some unusual patterns of water quality. Turbidity and TSS are not as strongly linked in this portion of the watershed as they are in other areas. Winter nitrogen concentrations are much greater than summer concentrations, suggesting either point source discharges or groundwater loading. Even in areas with riparian forests, groundwater nitrogen leaching can be higher in winter, a time when relatively little growth is occurring, reducing the effectiveness of trees at removing nitrogen from the groundwater. Total phosphorus appears to be non-seasonal, with stable, and moderately elevated concentrations, throughout the year. Spring and summer-fall bacteria concentrations show some evidence of elevated levels, but data are limited and more samples will need to be taken to confirm this finding.

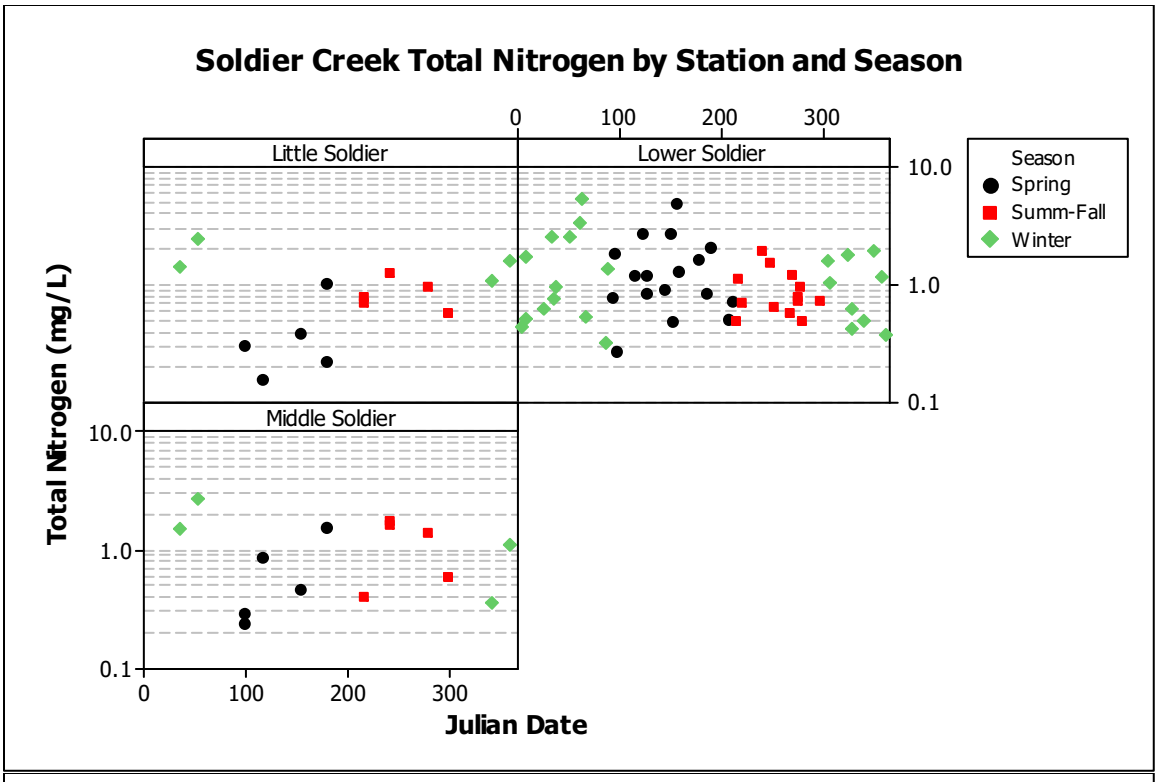
Lower Soldier Creek appears to be benefiting from some improvement relative to the Middle Soldier monitoring station with regards to TSS, turbidity, total phosphorus (except during the winter), bacteria, and total nitrogen (except during the spring). The largest and most robust dataset for this watershed exists at this monitoring station, and it shows the typical non-point arch-type graphs when plotted by the Julian Date of sample collection. High flow events are associated with elevated concentrations of pollutants, regardless of season, with more high flow events during the spring and winter than the summer.

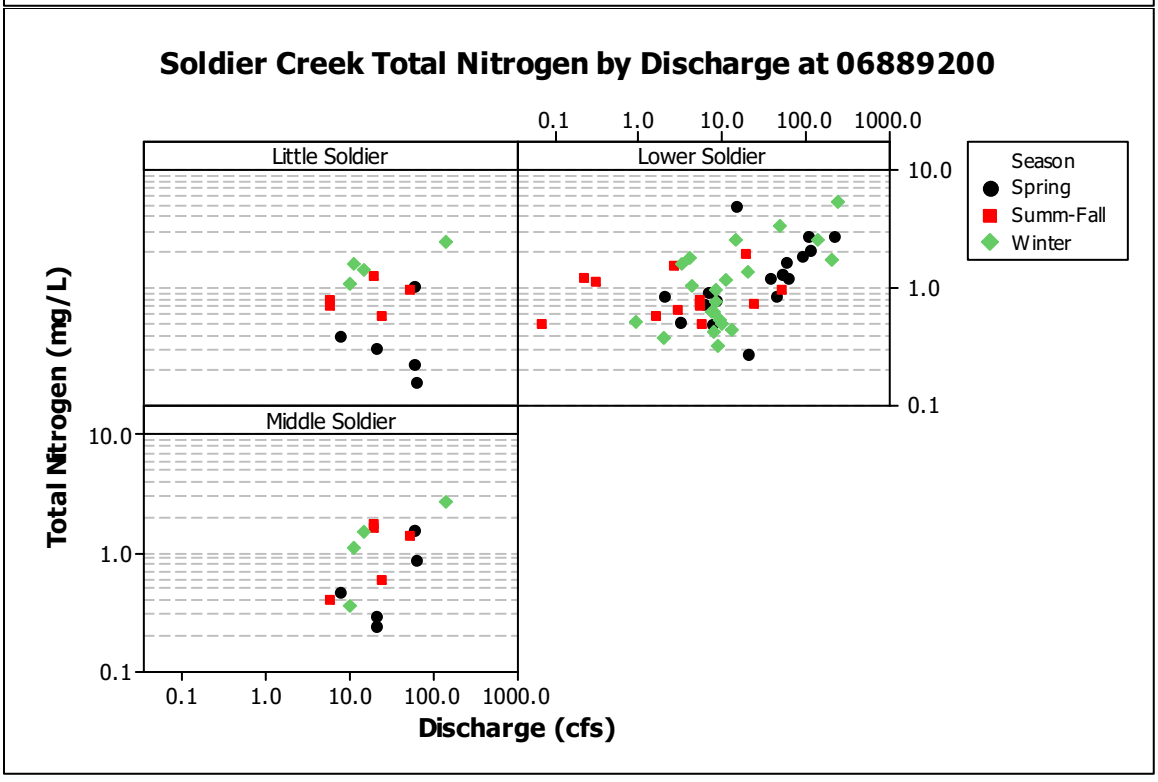
Site	Season	Turbidity Median	TSS Median	TP Median	TN Median	Kjeldahl Median	*E.coli* Median	TOC Median
Middle Soldier SC101	Overall	31.95 (72)	70 (69)	0.112 (72)	0.9975 (14)	0.5085 (14)	153 (7)	6.087 (13)
SC101	Spring	38 (26)	88 (25)	0.125 (26)	0.477 (5)	0.196 (5)	591 (3)	6.087 (5)
SC101	Summer-Fall	43 (18)	95.5 (18)	0.24 (18)	1.409 (5)	0.799 (5)	212 (2)	4.882 (5)
SC101	Winter	10 (28)	25 (26)	0.0555 (28)	1.324 (4)	0.654 (4)	81.5 (2)	8.054 (3)
Lower Soldier SC239	Overall	18 (157)	36.5 (154)	0.11 (157)	0.9455 (52)	0.64 (52)	132 (31)	5.36 (45)
SC239	Spring	22 (53)	49.5 (52)	0.123 (53)	1.212 (17)	0.693 (17)	132 (9)	6.211 (15)
SC239	Summer-Fall	21.35 (42)	40 (42)	0.135 (42)	0.742 (13)	0.587 (13)	146 (9)	4.29 (12)
SC239	Winter	9.15 (62)	20.5 (60)	0.0805 (62)	1.014 (22)	0.605 (22)	52 (13)	5.713 (18)
Little Soldier SC685	Overall	15.2 (21)	24 (21)	0.101 (21)	0.8835 (14)	0.2935 (14)	393 (7)	5.083 (13)
SC685	Spring	10.4 (7)	26 (7)	0.093 (7)	0.313 (5)	0.163 (5)	458 (2)	5.083 (5)
SC685	Summer-Fall	29.6 (6)	21.5 (6)	0.1105 (6)	0.784 (5)	0.463 (5)	441 (3)	3.873 (5)
SC685	Winter	8.9 (8)	18.5 (8)	0.113 (8)	1.521 (4)	0.771 (4)	10 (2)	8.18 (3)

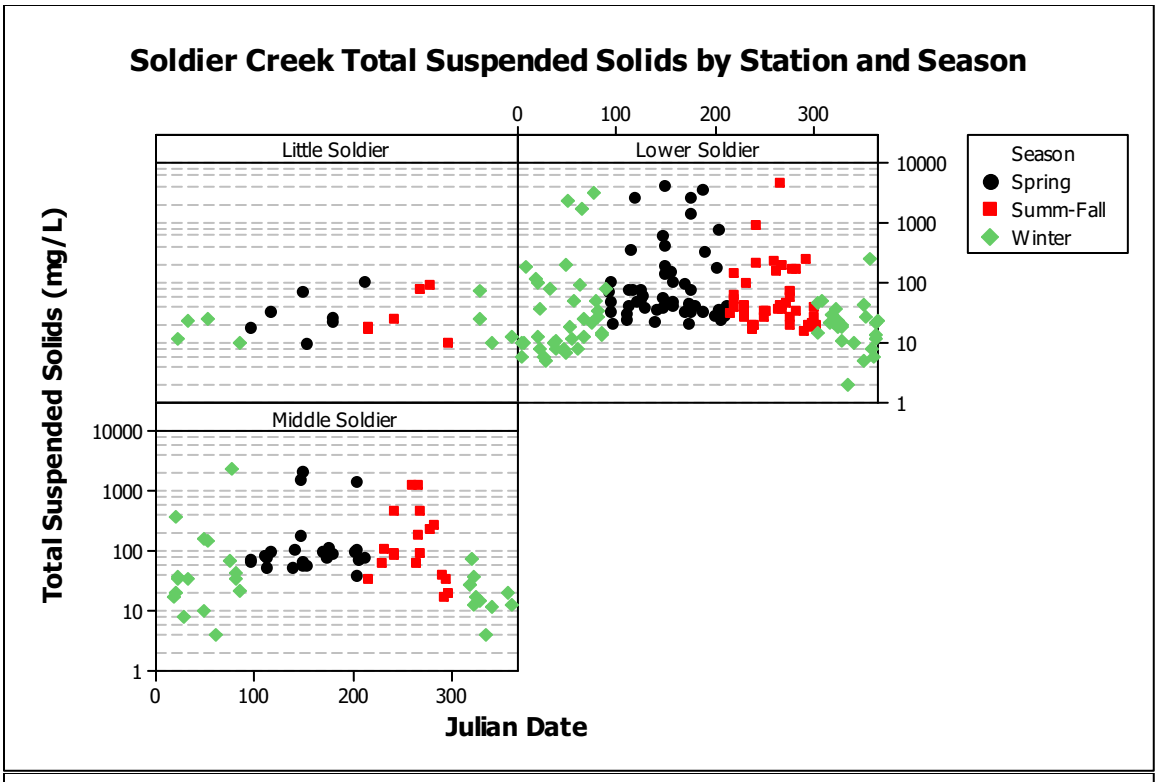
Soldier Creek stream chemistry data by season and overall at all three KDHE monitoring stations in the watershed. Number in parenthesis is sample size.

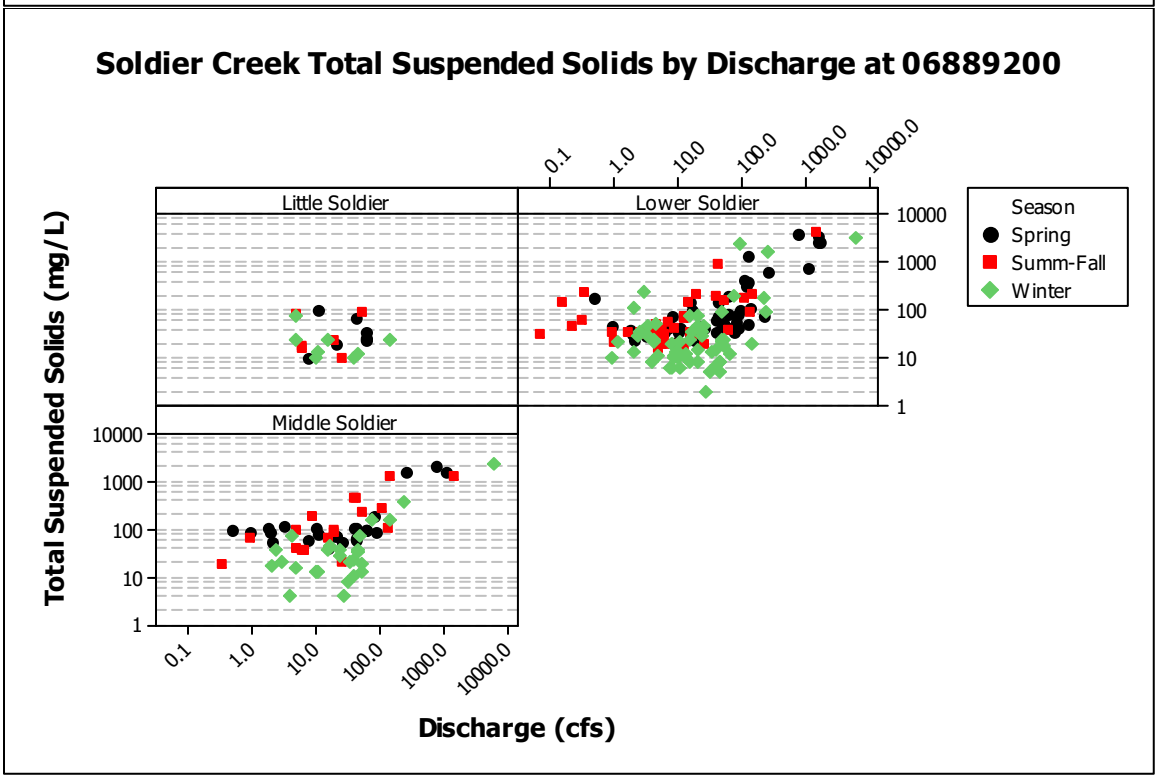

Soldier Creek Total Phosphorus by Station and Season
Little Soldier
Lower Soldier
Middle Soldier
Total Phosphorus (mg/L)
Julian Date
Season
Spring
Summ-Fall
Winter

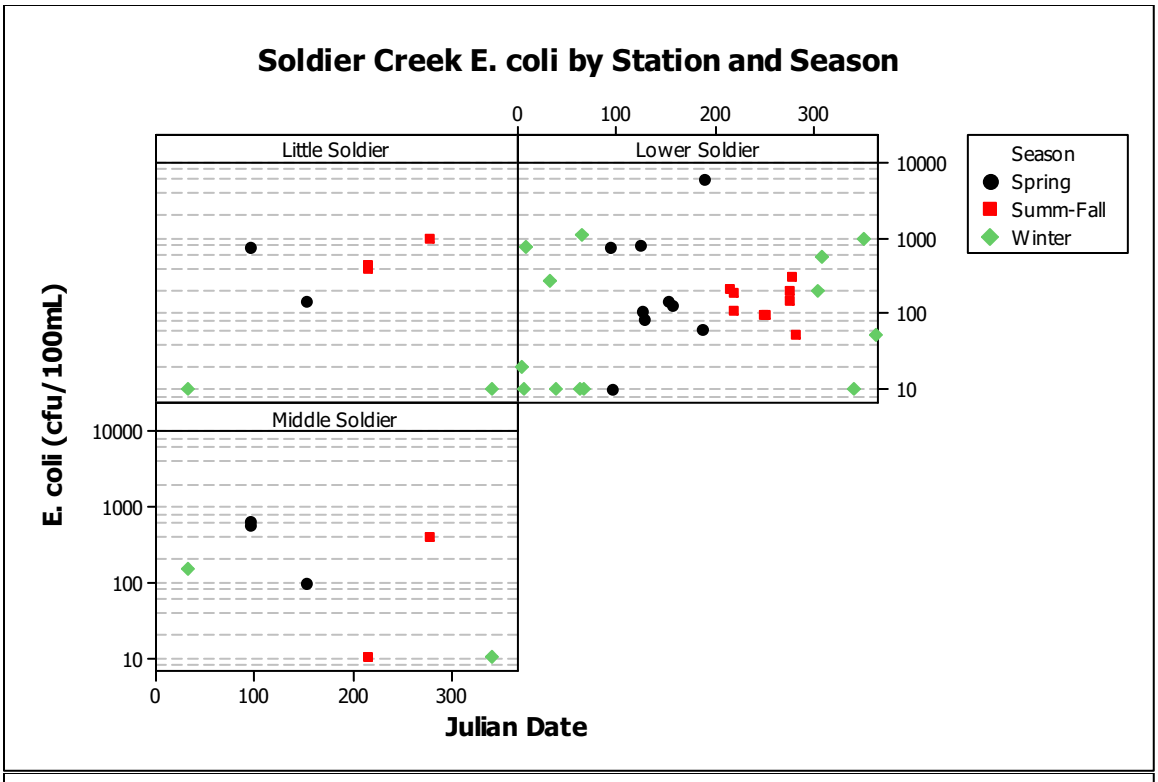

Soldier Creek Total Phosphorus by Discharge at 06889200
Little Soldier
Lower Soldier
Middle Soldier
Total Phosphorus (mg/L)
Discharge (cfs)
Season
Spring
Summ-Fall
Winter

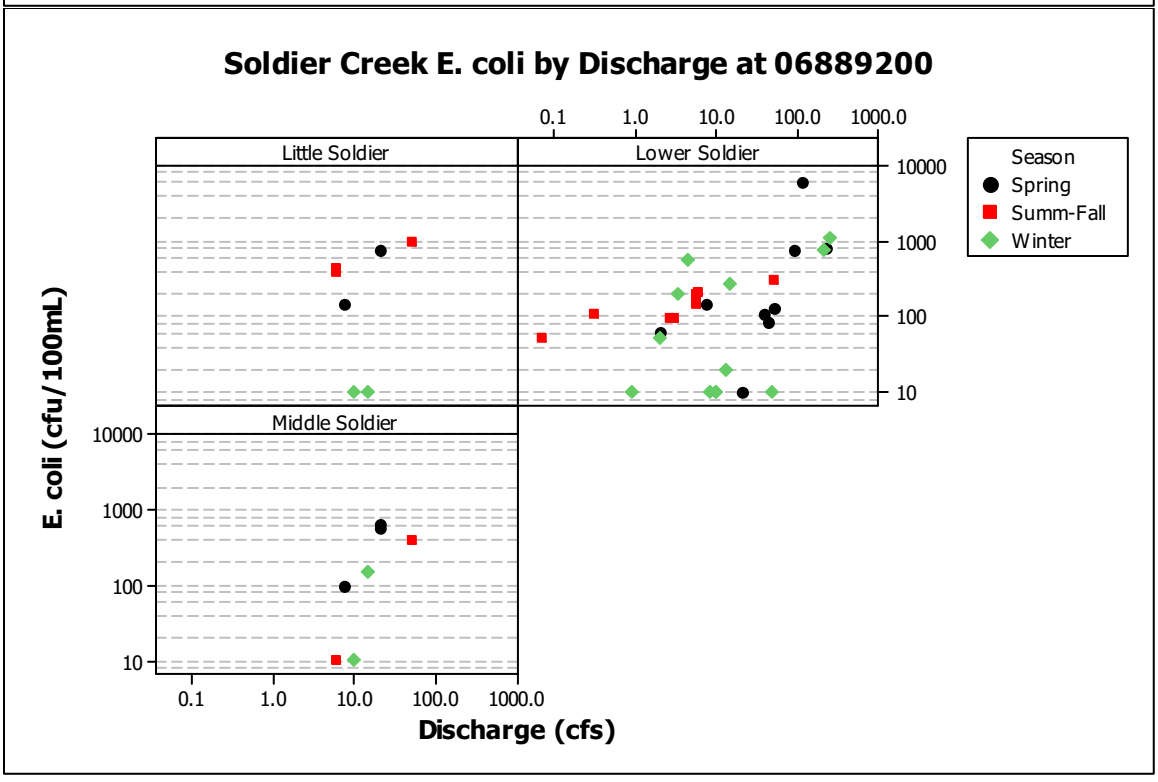

Soldier Creek Total Nitrogen by Station and Season
Little Soldier
Lower Soldier
Middle Soldier
Season
Spring
Summ-Fall
Winter
Total Nitrogen (mg/L)
Julian Date
0
100
200
300
10.0
1.0
0.1

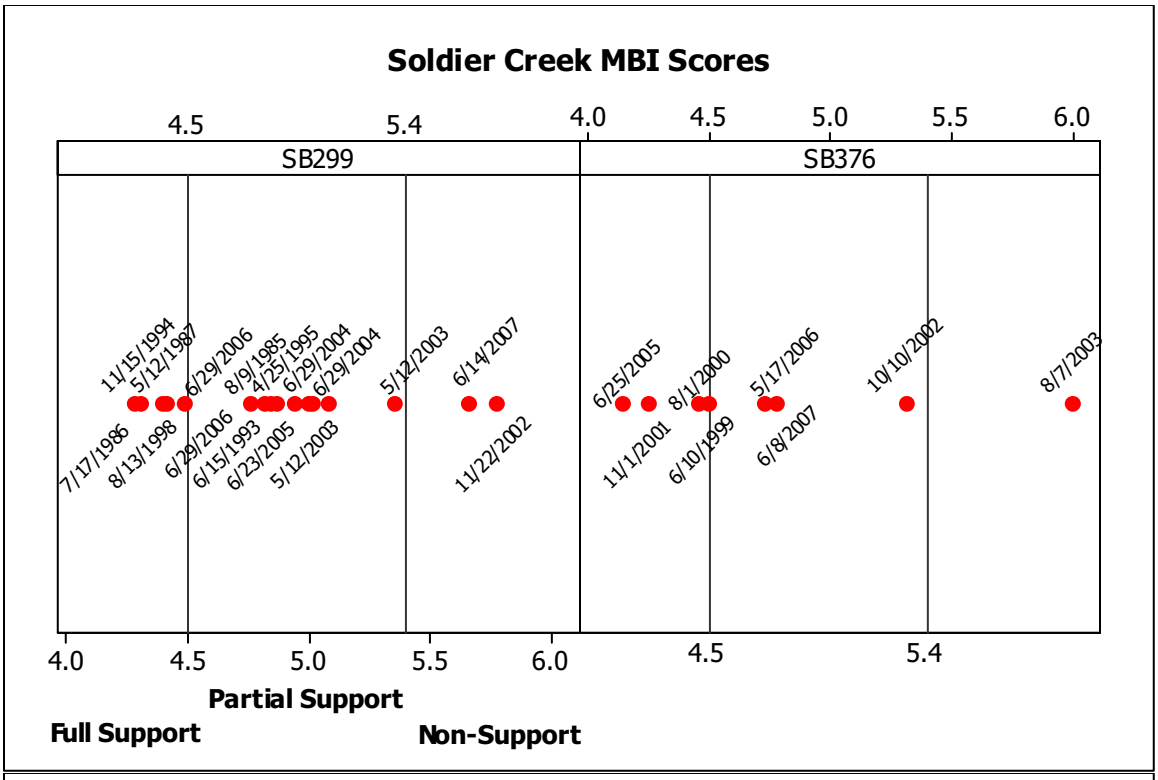

Soldier Creek Total Nitrogen by Discharge at 06889200
Little Soldier
Lower Soldier
Middle Soldier
Season
Spring
Summ-Fall
Winter
Total Nitrogen (mg/L)
Discharge (cfs)
0.1
1.0
10.0
100.0
1000.0

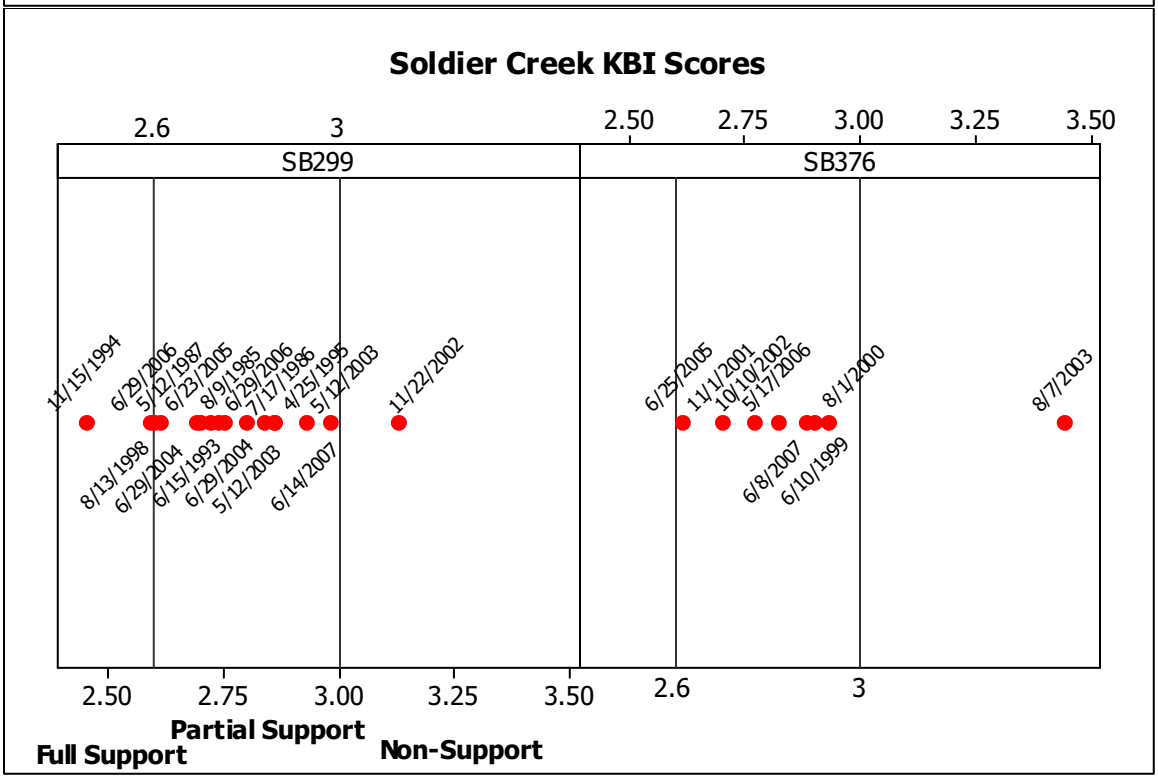

Soldier Creek Total Suspended Solids by Station and Season
Little Soldier
Lower Soldier
Middle Soldier
Total Suspended Solids (mg/L)
Julian Date
Season
Spring
Summ-Fall
Winter

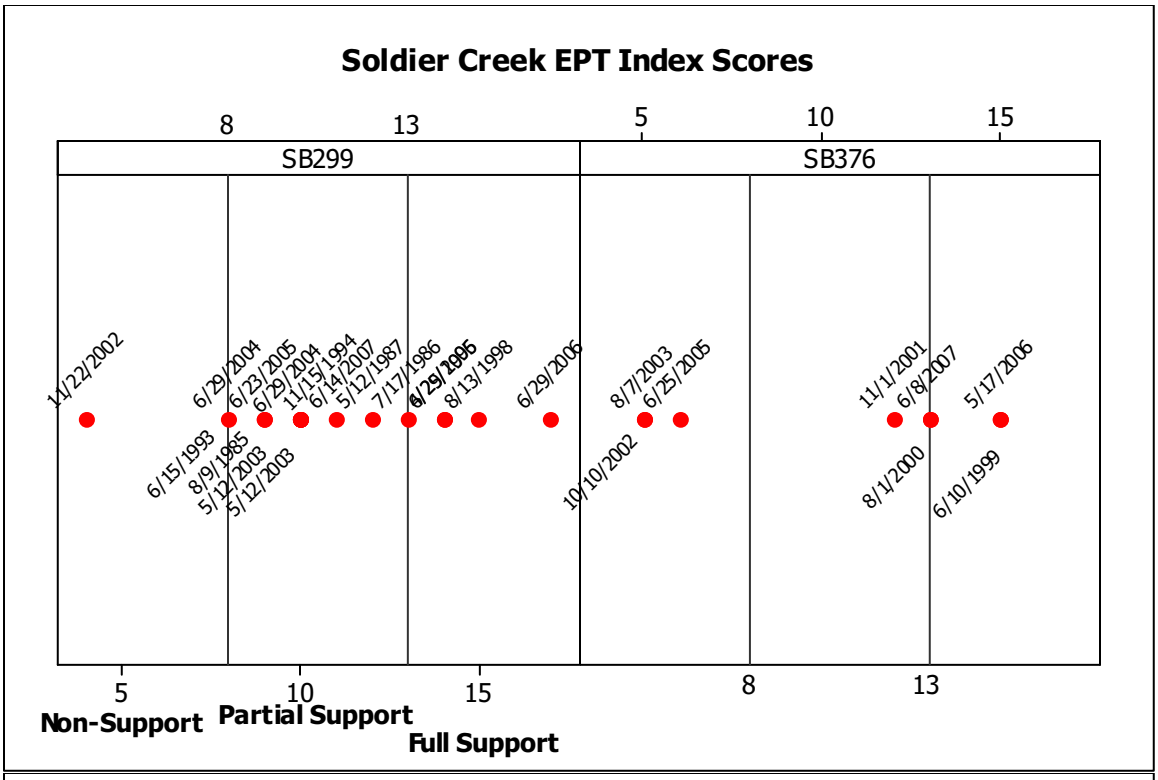

Soldier Creek Total Suspended Solids by Discharge at 06889200
Little Soldier
Lower Soldier
Middle Soldier
Total Suspended Solids (mg/L)
Discharge (cfs)
Season
Spring
Summ-Fall
Winter

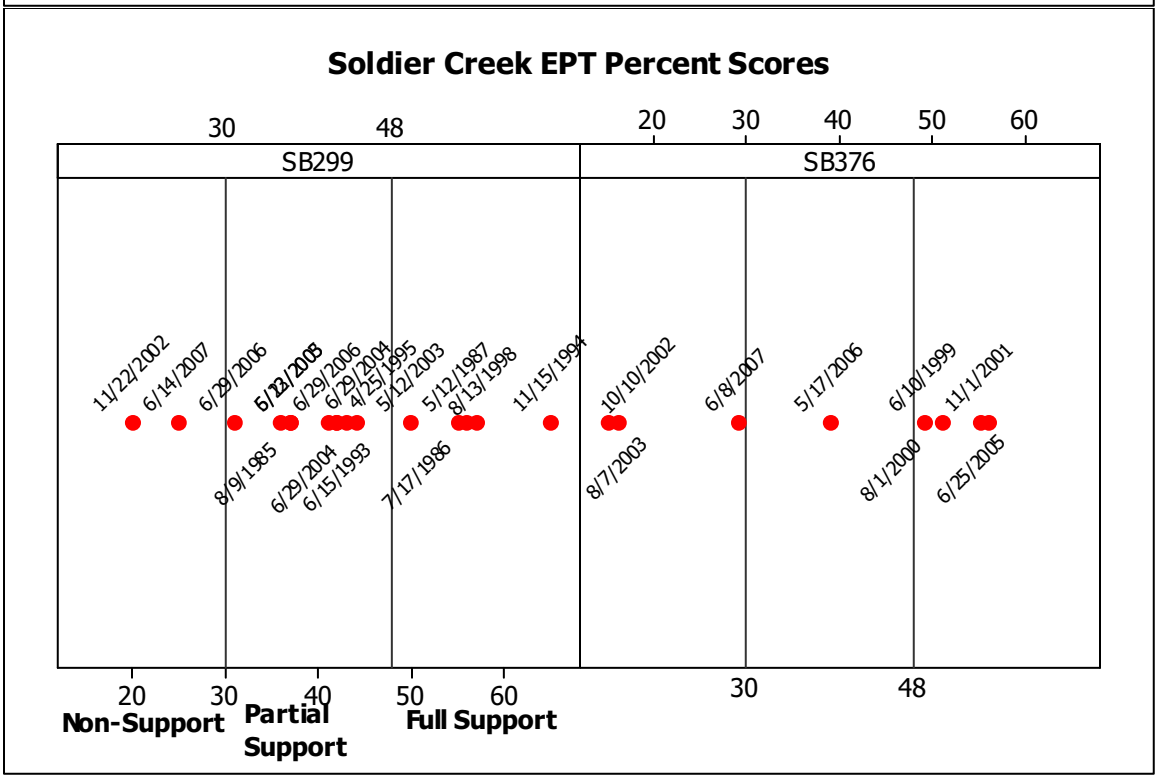

Soldier Creek E. coli by Station and Season
Little Soldier
Lower Soldier
Middle Soldier
Season
Spring
Summ-Fall
Winter
E. coli (cfu/100mL)
Julian Date
0
100
200
300
10
100
1000
10000


Soldier Creek E. coli by Discharge at 06889200
Little Soldier
Lower Soldier
Middle Soldier
Season
Spring
Summ-Fall
Winter
E. coli (cfu/100mL)
Discharge (cfs)
0.1
1.0
10.0
100.0
1000.0
10
100
1000
10000


Soldier Creek MBI Scores
4.5
5.4
4.0
4.5
5.0
5.5
6.0
SB299
SB376
11/15/1994
5/12/1987
6/29/2006
8/9/1985
4/25/1995
6/29/2004
6/29/2004
5/12/2003
6/14/2007
7/17/1986
8/13/1998
6/29/2006
6/15/1993
6/23/2005
5/12/2003
11/22/2002
6/25/2005
8/1/2000
5/17/2006
10/10/2002
8/7/2003
11/1/2001
6/10/1999
6/8/2007
4.0
4.5
5.0
5.5
6.0
4.5
5.4
Partial Support
Full Support
Non-Support

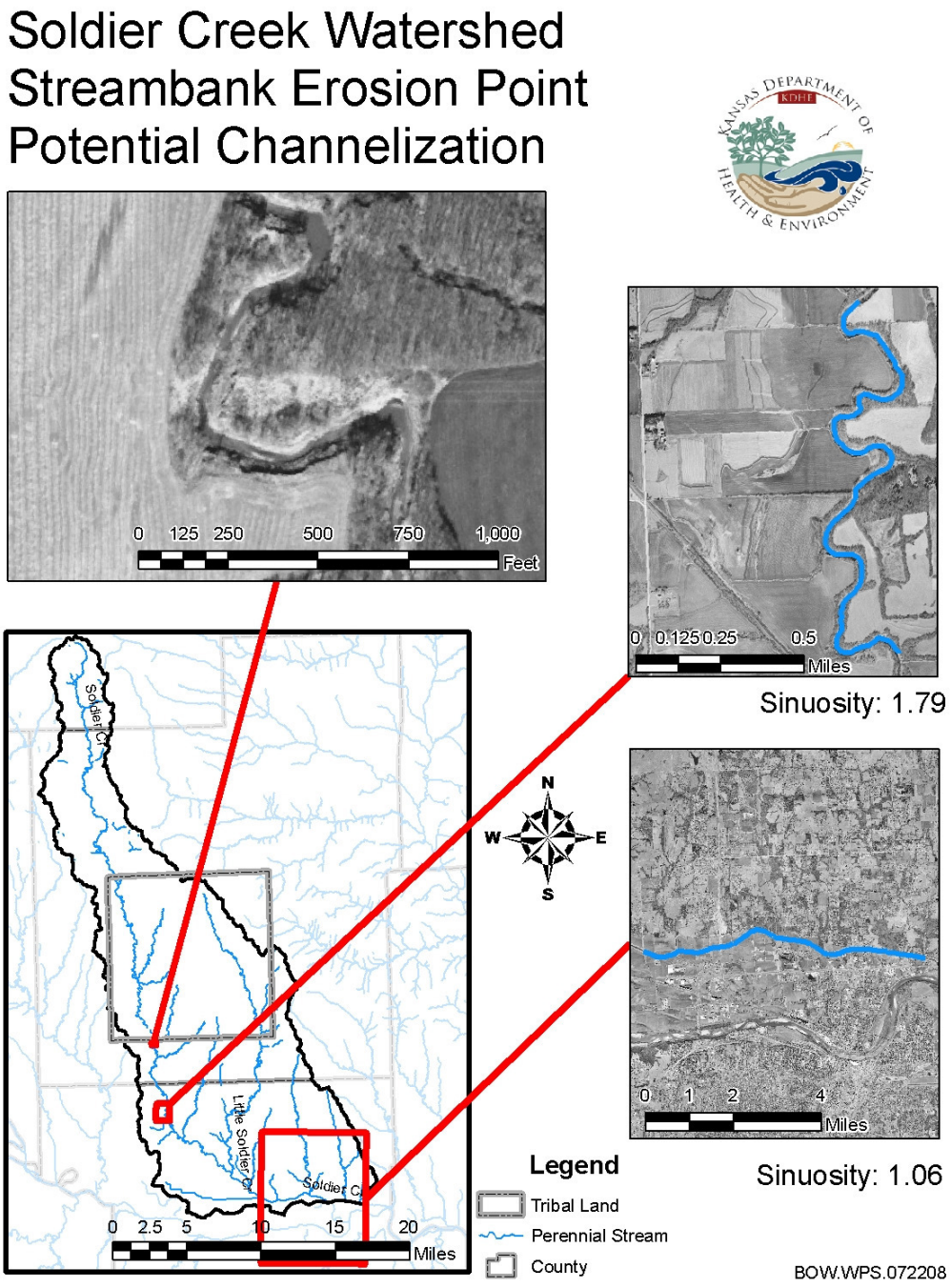

Soldier Creek KBI Scores
2.6
3
2.50
2.75
3.00
3.25
3.50
SB299
SB376
11/15/1994
6/29/2006
5/12/1987
6/23/2005
8/9/1985
6/29/2006
7/17/1986
4/25/1995
5/12/2003
11/22/2002
8/13/1998
6/29/2004
6/15/1993
6/29/2004
5/12/2003
6/14/2007
6/25/2005
11/1/2001
10/10/2002
5/17/2006
8/1/2000
8/7/2003
6/8/2007
6/10/1999
2.50
2.75
3.00
3.25
3.50
2.6
3
Partial Support
Full Support
Non-Support





Streambank stabilization may play an important role in improving water quality in the Soldier Creek watershed. Previous studies have documented the extensive channelization of the lower reaches of Soldier Creek, and subsequent headcutting along the main channel. In areas with poor buffering channelized reaches are particularly susceptible to

collapse. One meter resolution aerial photographs were used to identify a number of potential unstable streambanks in the lower reaches of the watershed



Uncertainty-

The availability of gage data concurrent with all the stream chemistry data and biology data reduce some of the uncertainty regarding water quality in this watershed.

The gage is co-located with only the most downstream of the stream chemistry sites, it is likely to be a good indicator of the relative flow conditions occurring in this watershed at the time of sampling. Because biology data is collected annually or less frequently there is less certainty regarding the applicability of the data across time. At this level of analysis we cannot assign sources to particular pollutants, though increasing nutrient and TSS concentrations moving downstream are correlated with increasing row-crop production, increasing population, and channelized stream reaches. It is also not possible at this level of analysis to determine the source of bacteria, leaving uncertainty regarding the relative contributions from septic systems, cattle and wildlife.

Adaptive Implementation Strategies-

Soldier Creek has a number of challenges facing the stakeholders in its watershed. The need to work with tribal government to coordinate water quality improvement measures is unique in the Mid-Kansas sub-basin. As noted previously, water quality is poor around the watershed, and the ongoing impacts of previous management decisions, particularly the channelization of the lower reaches of Soldier Creek, pose significant difficulties. In addition, the majority of the population in this watershed lives in and along the lower reaches of Soldier Creek, where significant semi-urban development is occurring, with the associated water quality concerns, including impacts from 5-20 acre ranchettes and management of on-site sanitary waste needs.

Reductions in sediment loading should provide concurrent relief from phosphorus loading, though nitrogen and bacteria appear to result from alternate sources. Reductions in sediment and phosphorus can be expected by improved management of riparian areas, and construction sites during development, as well as management activities that reduce the prevalence of bare ground. Promotion of reduced tillage strategies to row crop producers in the Soldier Creek watershed is one way to reduce surface runoff. Restoration of riparian buffers, designed with both heavily treed areas near the stream and permanent grass between the trees and any other activity will begin to provide some relief from near stream sources in this watershed. Over extended periods of time Soldier Creek will likely attempt to regain some of the channel length lost during the channelization of the lower reaches, absent any active attempts to constrain the stream to its existing channel.

Little Soldier and Middle Soldier show some potential evidence of bacteria contamination during spring and summer periods. Provision of alternative watering sites and exclusion of cattle from streams will likely reduce the bacteria concentrations observed in these areas. Other beneficial effects may be noted from reduction to livestock access, including reduced bank trampling, which may also improve water quality with regards to sediment and nutrients.

Nitrogen concentrations in this watershed show some evidence of elevated groundwater concentrations, with regard to acceptable surface water quality. While no evidence is currently available to suggest a problem with drink water supply needs, nitrogen concentrations during winter periods are elevated relative to spring and summer, suggesting a groundwater source. Improved soil testing and targeted application rates of

nitrogen fertilizers by agricultural producers can be expected to provide some reduction in this regard, though changes typically occur over a period of decades, as groundwater transport is slow. With the growing population in the lower reaches of Soldier Creek, proper management of on-site sanitary waste systems by residential homeowners will take an increasingly important role in managing loading of nutrients to groundwater.

Outreach and education efforts targeted at residential homeowners will likely be needed to ensure that these stakeholders engage in responsible land management, including pest control, turf management and fertilizer usage. Some anecdotal accounts suggest that improvements could also be made at the Shawnee County landfill, which has been identified as a potential source of sediment to nearby streams.

While tribal lands fall outside the jurisdiction of the state of Kansas, the residents of those areas are integral parts of improved conditions in this watershed. All of the general comments noted above apply equally to tribal lands, though mechanisms to implement them may differ due to alternative oversight and implementation sources.